Meteorite Hints at Early Life on Mars

For 8 years, a meteorite discovered in an Antarctic ice field languished in a storage cabinet at NASA's Johnson Space Center in Houston. Now, a 2-year analysis of that rock, believed to hail from Mars, offers tantalizing evidence that primitive life existed on the Red Planet some 3.6 billion years ago.

Scientists have long speculated that the planet, cut by long, sinuous channels that might be dry riverbeds, may once have been a warmer, wetter place that supported some form of life.

In an article scheduled for the Aug. 16 SCIENCE, researchers describe an array of intriguing findings from the meteorite ALH84001, the oldest of the 12 rocks thought to have fallen to Earth from Mars. The team discovered organic molecules that might be associated with life, several minerals characteristic of biological activity, and tiny tubular and egg-shaped structures that resemble the fossils of ancient, single-celled bacteria found on Earth. Moreover, all of these compounds and structures lie within a few hundred thousandths of a centimeter of each other.

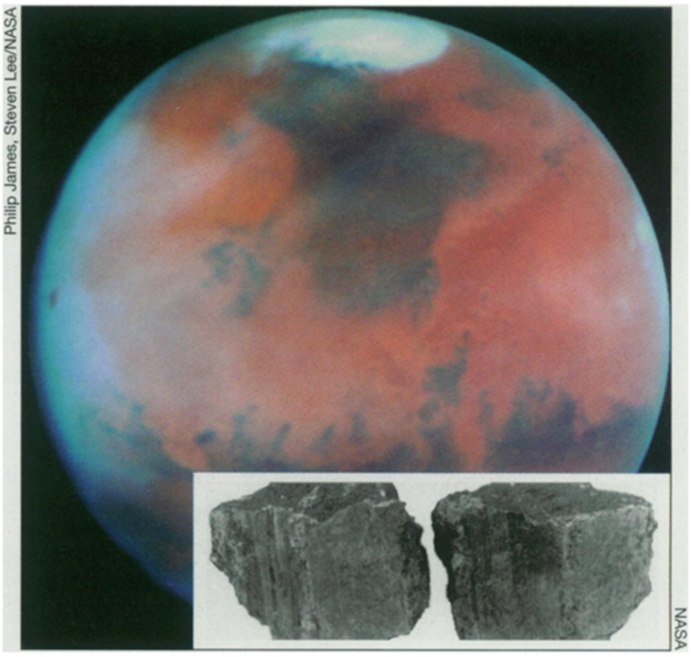
Examined separately, each finding might have a nonbiological explanation, but taken together, "all explanations except life seem far-fetched," asserts study coauthor Richard N. Zare of Stanford University.

"The evidence is exciting, even compelling, but not conclusive," says NASA administrator Daniel S. Goldin. "NASA is ready to assist the process of rigorous scientific investigation and lively scientific debate that will follow this discovery."

"They've done a very respectable paper," comments Allan H. Treiman of the Lunar and Planetary Institute in Houston. "They have a number of observations that could be indicative of [ancient] life." If the new findings were in Earth rocks, he adds, "people would say 'you've got intriguing evidence, but you haven't proved it yet.'"

"It is very difficult to prove life existed 3.6 billion years ago on Earth, let alone on Mars," notes Zare. "The existing standard of proof, which we think we have met, includes having an accurately dated sample that contains native microfossils, mineralogical features characteristic of life, and evidence of complex organic chemistry."

In studying the fractured surface of the meteorite, the team used laser spectroscopy and electron microscopy to measure minute concentrations of organic compounds and to image structures less than one-hundredth the thickness of a human hair. Recent advances in these techniques enabled the team to detect indications of life not seen in previous studies of ALH84001 or other Martian meteorites, they say.



Philip James, Steven Lee/NASA

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Mars viewed by the Hubble Space Telescope. Inset: Pieces of the Martian meteorite ALH84001 stored at the Johnson Space Center.

The team found two distinctive compounds—iron sulfide and magnetite—that on Earth are commonly produced by anaerobic bacteria and other microscopic organisms. Moreover, the compounds were found in the same tiny region that contains carbonate globules and possible bacterial fossils. The Martian microfossils are similar in shape to, though slightly larger than, those produced by the tiniest known terrestrial bacteria. Fossils formed by nanobacteria have been discovered in calcite deposits from ancient groundwater in southern Italy.

The first suggestion that ALH84001 might contain evidence of ancient Martian life came more than a year ago, when the same researchers reported that they had detected carbonates and organic molecules known as polycyclic aromatic hydrocarbons (PAHs) concentrated in some areas of the 1.9-kilogram meteorite (SN: 3/25/95, p. 180). On Earth, PAHs are produced by the decay or combustion of plants and other organisms.

Some researchers have argued that the Antarctic ice field in which ALH84001 landed some 13,000 years ago could have contaminated the meteorite with terrestrial PAHs or other organic materials. But the team's analysis shows that the concentration of PAHs increases from the meteorite's crust to its interior—exactly the opposite pattern one would expect if the organic molecules were foreign contaminants.

"We're very confident that we're not looking at PAH contamination," says Zare.

The team has suggested that the carbonates formed on Mars some 3 billion years ago, when water rich in dissolved carbon dioxide percolated through the rock. Other researchers have raised doubts about whether water, a compound associated with life on Earth, necessarily played a role.

In the July 4 NATURE, Ralph P. Harvey of Case Western Reserve University in Cleveland and Harry Y. McSween Jr. of the University of Tennessee in Knoxville argue that carbonates might have formed in the absence of water. They propose that about 1 billion years ago, an asteroid smashed into the Martian surface, heating some of the planet's abundant reserves of carbon dioxide frost and ice to a temperature as high as 700 kelvins. The heat would have vaporized any liquid water and sent a pulse of hot carbon dioxide fluid into the planet's crust, where it would have reacted to form the carbonates recently discovered in the meteorite.

Such debate is certain to continue. "We are putting this evidence out to the scientific community for other investigators to verify, enhance, attack—disprove if they can," says David S. McKay, a coauthor of the SCIENCE article, who is at the Johnson Space Center.

Three Mars-bound spacecraft—two U.S. and one Russian—are scheduled for launch this fall. Of these, NASA's Mars Pathfinder, which will land a rover on the planet to collect soil samples, holds the most promise of finding other clues of past or present life on Mars, Treiman says.

"There are certain defining moments of an age," says Zare. "The discovery, if it proves to be such, that we are not alone, would be such a defining moment."

—R. Cowen